Galactic star formation and supermassive black hole masses

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A simulation of the stellar content of the universe today seen across one hundred million light-years. Astronomers used this simulation to investigate how accretion onto a supermassive black hole quenches galaxy star formation. Credit:

Astronomers studying how star formation evolved over cosmic time have discovered that quiescent galaxies (galaxies that are currently not making many new stars) frequently have active galactic nuclei. These AGN accrete material onto hot circumnuclear disks, and the resultant energy is released in bursts of radiation, or as jets of particles moving at close to the speed of light. The suspicion is that these outbursts drive gas outflows over thousands of light-years, disrupting and dispersing potential star forming material in a process called quenching. The quenching mechanism is in addition a self-limiting one since the dispersion ultimately suppresses the gas accretion onto the black hole itself. There are other proposed mechanisms for quenching however: supernovae produced during star formation could be responsible (or at least an important contributor) as could strong stellar winds. Verifying these various alternatives is hence a key goal of galactic research.

CfA astronomers Bryan Terrazas, Rainer Weinberger and Lars Hernquist and their colleagues used the large-scale hydrodynamic simulation called IllustrisTNG to trace the development of galaxies and their black holes, in particular to investigate the correlations between black hole feedback and the suppression of star formation. Although the details of black hole accretion are still only sketchily understood, the simulation allows scientists to vary many input parameters of the simulation to test a range of alternatives.

The astronomers find that galaxies in the local universe with more than about ten billion masses of stars will indeed tend to quench star production once the energy in the winds from black hole accretion becomes larger than the gravitational energy in the gas, and that this tends to happen when the mass of the supermassive black hole exceeds

about one hundred and sixty million solar masses. This value appears to be quite sharply delineated: 90% of galaxies with smaller black holes are actively star forming and 90% of galaxies with larger black holes are quiescent. The team then compared the results of the simulations to observations of ninety one galaxies (although not a completely representative sample of objects) and finds generally good agreement; however, the observations show a much larger range of behavior.

More information: Bryan A Terrazas et al. The relationship between black hole mass and galaxy properties: examining the black hole feedback model in IllustrisTNG, *Monthly Notices of the Royal Astronomical Society* (2020). DOI: 10.1093/mnras/staa374

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